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GB 1598269
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GB 1444023
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(71) Applicant
General Electric Company (USA-New York), 1 River Road, Schenectady 12305, State of New York, United States of America
(72) Inventor
Peter Dexter Johnson
(74) Agent and/or Address for Service
Paul M. Turner & Company, 47 Marylebone Lane, London W1M 6DL

(54) Control of radial distributions in high intensity discharge lamps

(57) In a high pressure arc discharge lamp including one or more vaporized metal species, the radial distribution of metal atoms is controlled through the addition of a select amount of halide of the said metal species. In particular, in high pressure sodium lamps the density of sodium atoms near the arc tube wall is controlled through the addition of sodium iodide to reduce self-absorption of the plasma radiation by the sodium atoms. Alternative metal species are cassium, rubidium and potassium. The filling also contains Hg and an inert starting gas such as argon, krypton, xenon or neon. Thallium may also be present. Resistance heaters 41 may be provided to heat the ends of the arc tube 10.

FIG. 3

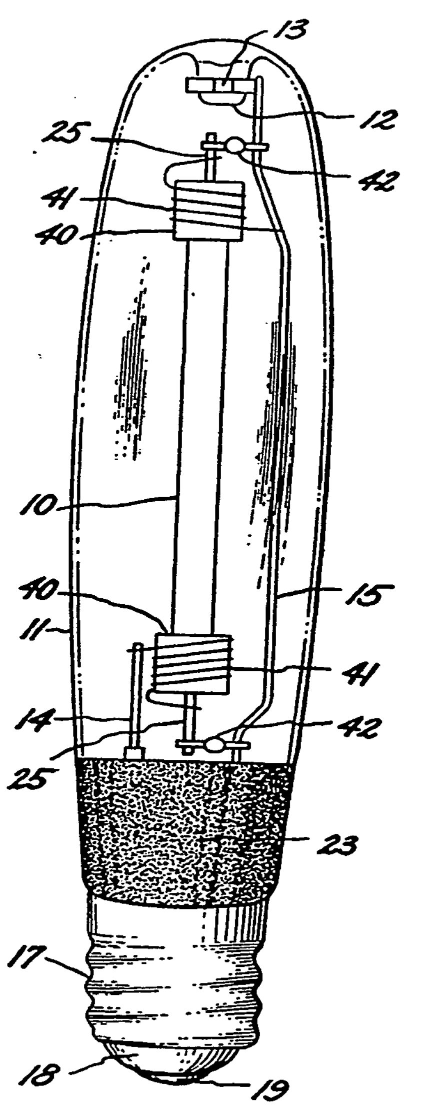

FIG. 1

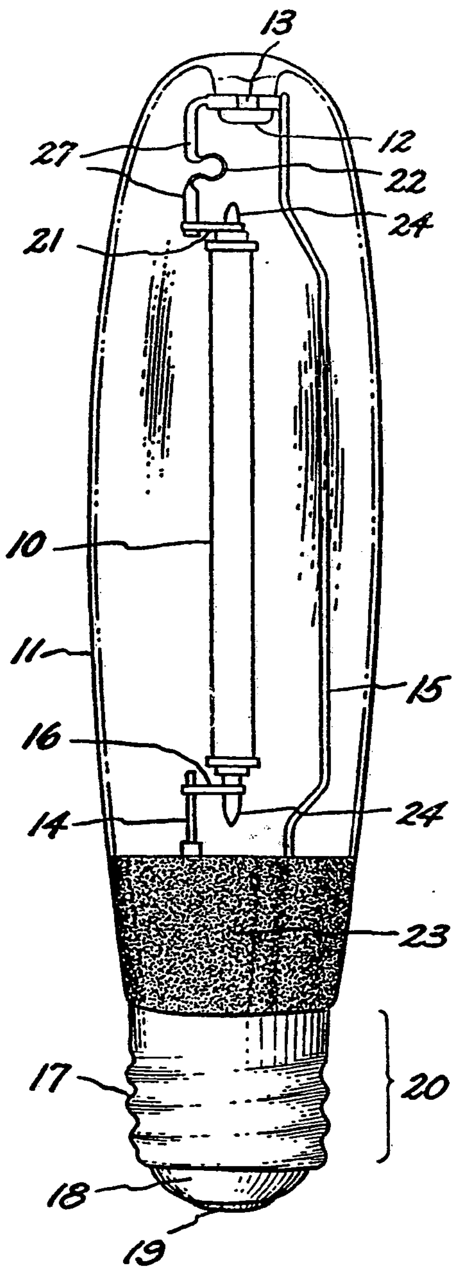
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FIG. 2

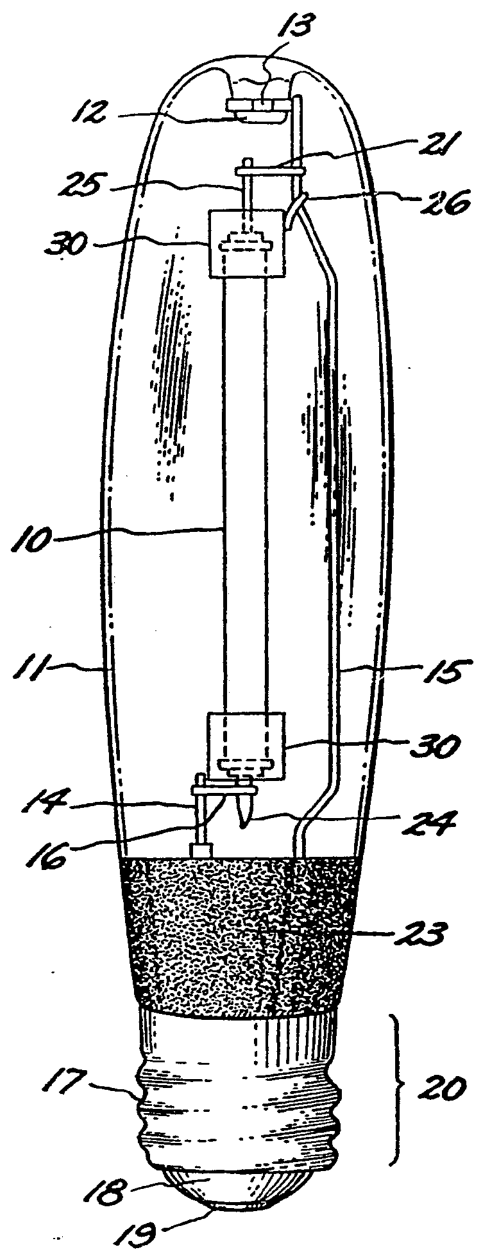
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FIG. 3

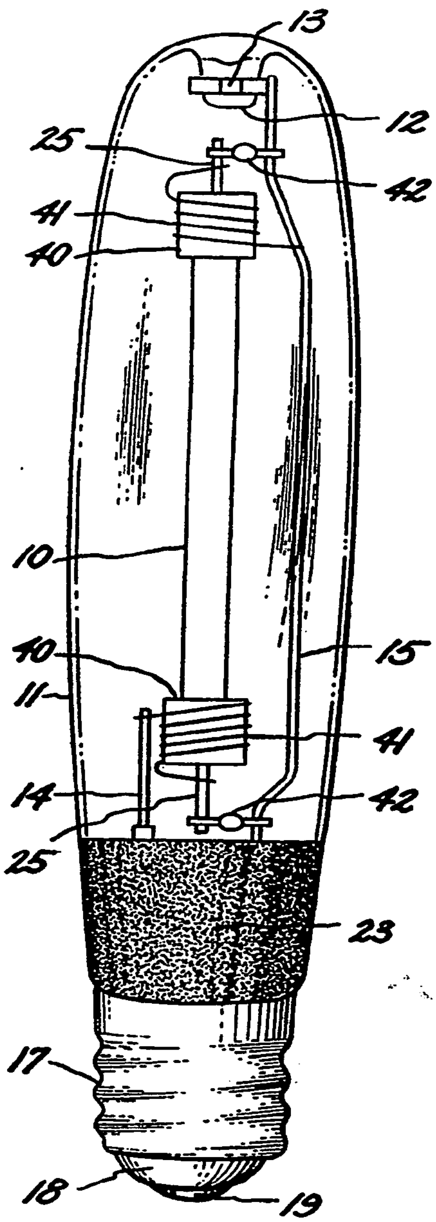


FIG. 4

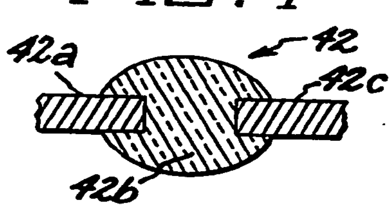


FIG. 5

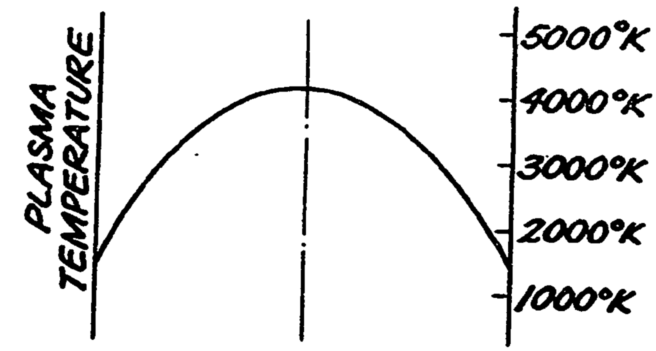
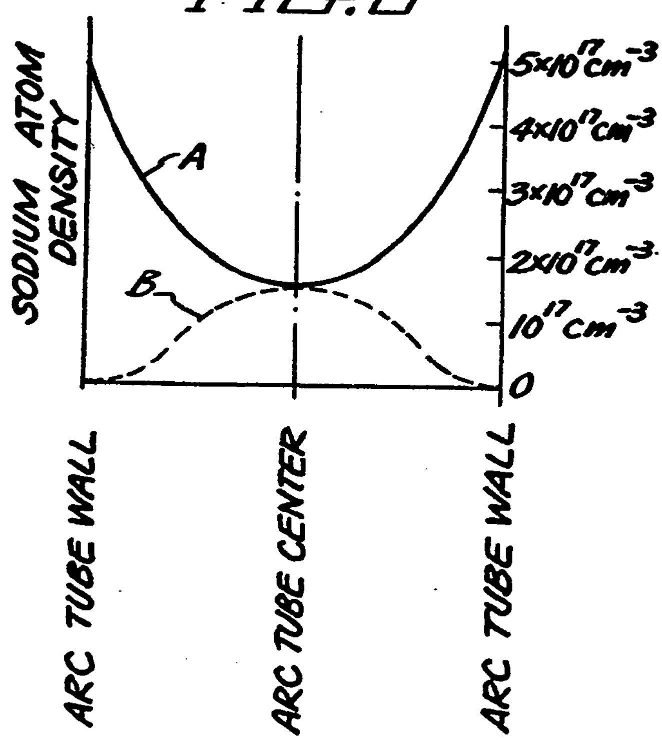


FIG. 6



SPECIFICATION

Control of radial distributions in high intensity discharge lamps

The present invention is related to high pressure metal vapor arc discharge lamps, and in particular, to controlling the radial distribution of metal ion species within the arc discharge tube.

High intensity arc discharge lamps comprise a class of lamps whose radiated light output is derived from a plasma arc discharge within an arc tube. One member of this class of lamps is the high pressure sodium vapor lamp. The present invention is most closely related to this form of high intensity discharge lamp. Accordingly, this form of lamp is more thoroughly discussed below. However, another form of high intensity discharge lamp that is currently and conventionally employed is the metal halide lamp. In such lamps the arc discharge tube includes a metal halide, such as sodium iodide, which is vaporized and dissociated during lamp operation. Accordingly, from the above it is seen that both metal vapor and metal halide arc discharge lamps are known in the lamp arts. However, the lamp of the present invention may best be described as a metal plus metal halide (metal/metal halide) lamp. From the discussions below, it will be seen that such metal plus metal halide lamps exhibit unique characteristics not found in previously disclosed high intensity arc discharge lamps. It will also be seen that the lamp of the present invention exhibits a controlled radial distribution for atoms of the vaporized metal species.

With respect to the high pressure sodium lamp, it has been seen that the self-absorption characteristics of cooler sodium atoms distributed preferentially near the cooler arc tube walls acts to limit lamp efficacy. In particular, sodium D line radiation produced within the hot central plasma region of the arc tube is readily absorbed by the cooler sodium atoms present near the arc tube walls. This phenomenon has been known in the lamp arts, and solutions to the problem have been considered by several experimenters. For example, in a paper titled "Analysis of Factors Affecting Efficacy of High Pressure Sodium Lamps" by Waymuth and Wyner in Vol. 10, Pages 237—244 of the Journal of the Illuminating Engineering Society (July 1981), they have suggested reducing the sodium density near the arc tube wall by keeping the wall hot, through the use of wall material having a low infrared emissivity. In application Serial No. 298,838 filed September 3, 1981, the present inventor has disclosed the use of infrared reflecting films disposed on the interior of the outer jacket for the purpose of maintaining an elevated wall temperature to at least partially reduce the effects of radiation reabsorption by cooler metal atoms which preferentially tend to accumulate near the cooler arc tube walls, rather than within the hot central plasma discharge r gion. Other experimenters have also considered the ffects of the arc tub diameter on lamp efficacy and have included in their considerations the self-absorption of radiation by the sodium atom. However, other than by the control of arc tube wall temperature there is no other prior suggestion of means to control this absorption phenomena.

In accordance with a preferred embodiment of the present invention a high intensity arc discharge lamp comprises an outer light transmissive envelope, a light transmissive arc discharge tube with electrodes at opposite ends of the arc tube and means to provide electrical connections to the electrodes. Furthermore, and more importantly, the arc discharge lamp of the present invention includes a vaporizable discharge medium disposed within the arc tube, the discharge medium including quantities of mercury and inert starting gas, as described more particularly below, together with one or more vaporizable metal species disposed within the arc tube and also together with a halide (other than a fluoride) of the metal species. In particular, in a preferred embodiment of the present invention the metal species comprises sodium and the halide is an iodide. In operation, substantially all of the sodium iodide in the center of the plasma arc is dissociated, but none of the sodium iodide at the arc tube wall is dissociated. Since the metal halide species in the proximity of the arc tube wall does not preferentially absorb the radiation produced at the center of the discharge tube, a significant loss of lamp efficacy is eliminated. Furthermore, control of the ratio of the partial pressure of sodium to the partial pressure of sodium iodide may now be employed to actually control the radial distribution of sodium atoms. In preferred embodiments of the present invention there is included means to provide a higher than conventional arc discharge tube reservoir temperature because of the higher temperatures generally required for vaporization of the metal halide.

Accordingly, it is also seen that another embodiment of the present invention comprises a method for controlling the radial distribution of a vaporized metal species in a high intensity discharge lamp arc tube through the inclusion within the arc tube of a selected quantity of a halide, other than a fluoride of the metal species. In particular, fluorides are typically not useful in lamp devices because of their great proclivity to attack and erode the material of the discharge arc tube and the electrodes.

The present invention attempts to provide a high intensity arc discharge lamp exhibiting improved efficacy.

It is also an object of the present invention to provide a means for controlling th radial distribution of one or more vaporized metal species within an arc discharge tube.

It is a further object of the present invention to reduce the effects of radiation self-absorption which occurs within certain high intensity discharge lamps.

Lastly, it is an object of the present invention to provide a novel form of high intensity discharge

lamp which is referred to herein as a metal plus metal halide lamp or metal/metal halide lamp.

The present invention will b further described, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a side elevation view of a typical high pressure sodium vapor lamp in which the present invention may be embodied;

Figure 2 is a side elevation view of a lamp similar to that shown in Figure 1 except that reflective heat conserving end shields are provided;

Figure 3 is a side elevation view similar to Figure 1 except illustrating the presence of separate reservoir heating means provided at the ends of the arc discharge tube;

Figure 4 is a detailed illustration of the cross-sectional side elevation view of a standoff insulating support of the kind shown in Figure 3;

Figure 5 is a graph illustrating plasma temperature variation as a function of distance from the arc tube center;

Figure 6 is a graph illustrating sodium atom density (also as a function of distance from the arc tube center) for conventional metal vapor lamps in curve A and for certain lamps of the present invention in curve B.

Figure 1 illustrates a typical high pressure sodium arc lamp, or more generally, a typical high pressure metal vapor lamp. The configuration shown in Figure 1 is also employable with the present invention which is generally directed to the specific nature of the gaseous discharge medium. In particular, Figure 1 shows a high intensity arc discharge lamp comprising outer light transmissive envelope 11. This outer envelope preferably comprises a material such as heat resistant glass or quartz. The lamp shown also comprises light transmissive arc discharge tube 10 which has electrodes disposed internally at opposite ends thereof. Arc discharge tube 10 is typically configured in a cylindrical shape and must be resistant to attack by the materials employed in the gaseous discharge medium contained within the arc tube. In particular, arc discharge tube 10 preferably comprises a refractory ceramic material such as alumina, and more particularly, sintered polycrystalline alumina. This material has been shown to be very resistant to attack by metal species such as sodium. The arc discharge tube is typically between about 4 and about 18 millimeters in internal diameter. However, a diameter of between about 8 and about 10 millimeters represents an even more preferred range for the lamp and method of the present invention. Lastly, with respect to arc tube 10, it may be noted that it may in fact comprise a crystalline material such as sapphire. However, the use of such a material is generally prohibitively expensive except in applications where the high cost may be off-set by the needed advantages that such a material may provide. It is also to be noted that the volume between arc discharge tube 10 and outer envelop 11 is generally vacuat d to prevent efficacy robbing heat loss s from the arc tube.

While outer envelope 11 and arc tube 10 comprise the principal mechanical structure of a lamp in accordance with the present invention, other structures are contained therein for providing electrical connection and support for the arc tube. In particular, supporting wire conductor 14 provides part of a means for connecting the arc tube electrodes to external connections through conventional Edison base 20. Likewise conducting wire support 15 is also typically electrically connected to one of two external metal contacts on Edison base 20. Conducting wire support 15 extends upward through the vacuum region of the lamp and is preferably welded to hexagonal bracing washer or ring 13 which is disposed about dimple 12 provided in the end of outer envelope 11 to furnish support for arc discharge tube 10. Furthermore, because of thermal expansion effects which occur during lamp operation, a further support 27 possesses expansion loop 22. Supporting and conductive wire 27 is preferably spot welded to ring 13 and to lateral support wire 21 which is, in turn, preferably spot welded to arc tube termination 24 which may also serve as an amalgam or halide reservoir. Similarly, at the base end of the lamp shown in Figure 1 lateral support 16 is spot welded to conducting support wire 14 and to lower arc tube termination 24 so as not only to support arc tube 10 but also to supply electrical current to the electrodes therein. In this way, the current path through the gaseous discharge medium typically includes the following sequence: conductive support wire 14, lower lateral support 16, lower arc tube termination 24, the lower electrode in arc tube 10, the gaseous discharge medium within arc tube 10, the upper electrode in arc tube 10, upper arc tube termination 24, lateral support wire 21, vertical support 27 (including thermoexpansion loop 22), support ring 13, and lastly supporting wire conductor 15. Conductive wires 14 and 15 are separately connected to either or external metal screw base connection 17 or center exterior contact 19. External contact 17 and 19 are separated by insulating material 18. In this way, means are provided for electrical connection to the electrodes within arc tube 10. Furthermore, a typical lamp such as illustrated in Figure 1 also preferably includes a coating of getter material 23 disposed on the interior of outer envelope 11 to assist in maintaining vacuum conditions in the volume between arc tube 10 and outer envelope 11.

The description given above for the lamp illustrat d in Figure 1 is typical of a conventional high pressure metal vapor lamp, such as the high pressure sodium vapor lamp. It is in this general kind of lamp in which the present invention is most applicable. In particular, as discussed above, it has been found that there is an efficacy robbing re-absorption of radiation by cooler sodium atoms present near the arc tube wall. The radiation which is absorbed is produced near the center of the arc discharge tube as a result of the ionized sodium

vapor plasma. In particular, in this regard, attention is directed to Figures 5 and 6 which are discussed below. In the present invention, experiments have confirmed that the presence of a metal halide, such as sodium iodide in the arc tube of a sodium vapor lamp significantly reduces the reabsorption phenomena. In particular, sodium iodide in the center of the plasma arc is dissociated but none of the sodium iodide near the arc tube wall is dissociated. Thus, sodium atoms normally present near the arc tube wall which act to reabsorb radiation from the central plasma region are no longer present. Instead, in the present invention the iodide is present there and the iodide does not produce reabsorption problems. Accordingly, it is seen that by controlling the amount of metal halide added to the arc tube, and for example, the arc tube reservoir temperature, the partial vapor pressure of the metal halide may be controlled. In particular, it is seen that it is desirable to control the ratio of the metal vapor partial pressure to the metal iodide partial pressure. In this way the radial distribution of sodium atoms and ions may be controlled.

Additionally, it is particularly noted that the use of sodium iodide in a sodium vapor lamp, in accordance with the present invention, also readily lends itself to the inclusion of certain additives which contribute to the spectral output of the lamp and improves its color. In particular, thallium iodide may be added. As a result of this addition the following reversible reaction occurs within the arc tube:

$$TlI + Na \rightleftharpoons NaI + Tl$$

However, it is noted that the above reversible reaction implies that the addition of sodium iodide, to the arc tube fill, drives the reaction to the left. However, this enhances the spectral output from the metal whose iodide is added. In the invention described herein, the beneficial effect of sodium iodide on efficacy occurs independently of the presence of other iodides, such as thallium iodide.

As mentioned above, the arc tube employed in the lamp of the present invention should be resistant to attack by the metal species employed. Addionally, the metal halide that is added to the arc discharge tube in accordance with the present invention should be a halide other than a fluoride because fluorides are well known to attack the materials which are conventionally employed or employable in arc discharge tubes.

In accordanc with conventional practice in metal vapor lamps, a finite quantity of mercury is also preferably disposed within the arc tub in a sufficient quantity to produce a partial vapor pressure of up to about 10 atmospheres at lamp operating conditions. While certainly preferable, however, the inclusion of mercury is not absolutely necessary for the practice of the present invention. Additionally, like mercury, a finite quantity of an inert starting gas is also preferably disposed within the arc tube in sufficient quantity to produce a partial vapor pressure of between about 1 and about 200 Torr at lamp operating conditions. The inert starting gas is generally selected to be a gas such as argon, krypton, xenon or neon. The metal vapor that is employed in the lamps contemplated in the present invention include alkali metals such as sodium, cesium, rubidium and potassium.

Figure 2 illustrates a form of high pressure metal/metal halide lamp which is preferably employed in the present invention. In particular, the lamp of Figure 2 includes molybdenum heat shields 30 disposed about the ends of arc tube 10. In particular, since sodium halide requires a higher temperature than sodium metal, to maintain desired vapor pressures of the sodium iodide species, these heat conserving end shields are employed about the arc tube ends to achieve this purpose.

Figure 3 illustrates yet another form of high pressure metal/metal halide lamp which is preferred for use with the present invention. In particular, the lamp of Figure 3 includes electrical resistance coil heaters 41 disposed about heat resistant cylinder 40 comprising a material which may, for example, be similar to arc tube 10 or another ceramic material. While two of these coils are shown employed in the lamp of Figure 3, it should also be appreciated that a single resistive heater may also be employed. As shown in the figure the resistive heaters are connected electrically so as to be in series with the arc discharge between the electrodes in arc tube 10. To preserve this series electrical connection insulating supports 42, or similar configurations may be employed. Insulating support 42 serves to support discharge tube 10 through its attachment to arc tube termination lead 25, which is a form of arc tube termination which may be employed in those situations in which an external reservoir is not desired or required, at one or both arc tube ends. Insulating support 42 is typically spot welded to terminating leads 25 and electrically conductive support 15 and thus serves to support arc tube 10. However, it also serves an electrical insulating function to permit the connection of heating coils 41 in series with the discharge within arc tube 10. A detailed illustration of one form of such an insulating support structure is shown in Figure 4 in which it is seen that separate electrical support members 42a and 42c are disposed within a glass or ceramic bead 42b which acts to maintain electrical isolation between supporting metal portions 42a and 42c.

A further understanding of the problem of reabsorption in metal vapor lamps and an understanding of the solution put forth herein may be obtained through consideration Figures 5 and 6. Figure 5 is a graph of plasma temperature as a function of position across the diameter of the arc tube, the center of the graph corresponding to the center of the arc tube, and the end points of the graph corresponding t the end surface of the arc tube wall. Figure 5 illustrates the fact that the

plasma temperature obtains its maximum value of approximately 4,500°K at the cent r of the arc tube and that the plasma (ionized vapor) temperature falls off to approximately 1,500°K at the arc tube wall. More importantly, curve A in Figure 6 illustrates that the sodium atom density, in a conventional high pressure sodium lamp, is at a minimum value near the arc tube center but increases by a factor of about 2 or 3 as the inner surface of the arc tube wall is approached. It is the presence of these quantities of sodium atoms near the arc tube wall surface which contributes most significantly to the radiation absorption problem solved by the present invention. Curve B in Figure 6 illustrates the sodium atom distribution in a lamp which includes sodium iodide as the discharge medium. It will therefore be appreciated that the inclusion of sodium and sodium iodide in the discharge medium makes it possible to control and optimize the radial distribution of sodium atoms, or in general, a metal vapor species. For example, a gaseous discharge medium including xNa + yNaI makes it possible to produce sodium atom distributions lying between curves A and B in Figure 6.

From the above, it may be appreciated that the present invention provides a new form of high intensity discharge lamp. In particular, it has been seen that while metal vapor lamps such as sodium lamps have been employed in the past and that while lamps employing metal halides have also been employed, nonetheless, the present invention represents a novel form of lamp structure, described herein as a metal/metal halide lamp. The particular advantages of the present lamp include the fact that the presence of the metal halide, together with the metal vapor, reduces the metal atom density in the vicinity adjacent to the arc tube wall. This causes the lamp to exhibit a higher concentration of metal halide atoms which do not result in reabsorption of the radiation generated within the central, hot plasma. In particular, it is seen that the present invention is particularly applicable to the construction of sodium/sodium iodide lamps. Additionally, the present invention also permits the inclusion of certain color improving additives within the discharge tube.

While the invention has been described in detail herein, in accordance with certain preferred embodiments thereof, many modifications and changes therein may be effected by those skilled in the art. Accordingly, it is intended by the appended claims to cover all such modifications and changes as fall within the true spirit and scope of the invention.

CLAIMS

1. A high intensity arc discharge lamp comprising:

an outer light transmissiv envelope;

a light transmissive arc discharge tube having electrodes disposed at opposite ends thereof;

a quantity of mercury disposed within said arc tube in sufficient quantity to produce a partial vapor pressure of up to about 10 atmospheres at op rating conditions;

a finite quantity of an inert starting gas disposed within said arc tube in sufficient quantity to produce a partial vapor pressure of between about one and about 200 Torr at lamp operating conditions;

at least one vaporizable metal species disposed within said arc tube as an amalgam;

a halide, other than a fluoride of said metal species disposed within said arc tube, said arc tube being resistant to attack by said metal species; and

means to provide electrical connection to said electrodes.

2. The lamp as claimed in claim 1 in which said arc discharge tube comprises sodium resistant material.

3. The lamp as claimed in claim 1 in which said arc discharge tube comprises a refractory ceramic.

4. The lamp as claimed in claim 1 in which said arc discharge tube comprises sintered polycrystalline alumina.

5. The lamp as claimed in claim 1 in which said arc discharge tube comprises alumina.

6. The lamp as claimed in any one of the preceding claims in which said arc discharge tube is between 4 and 18 millimeters in internal diameter.

7. The lamp as claimed in claim 6 in which said arc discharge tube is between 8 and 10 millimeters in internal diameter.

8. The lamp as claimed in any one of the preceding claims in which said inert starting gas comprises a gas selected from argon, krypton, xenon and neon.

9. The lamp as claimed in any one of the preceding claims in which said metal species is selected from sodium, cesium, rubidium and potassium.

10. The lamp as claimed in any one of the preceding claims in which said metal species halide comprises sodium halide.

11. The lamp as claimed in any one of the preceding claims in which said means to provide electrical connection also supports said arc tube within said outer envelope.

12. The lamp as claimed in any one of the preceding claims further including heat shields disposed around the ends of said arc tube.

13. The lamp as claimed in any one of the preceding claims further including means to heat at least one end of said arc discharge tube.

14. The apparatus as claimed in claim 13 in which said heating comprises electrical resistance heaters disposed about the ends of said arc tube.

15. The lamp as claimed in claim 14 in which said heaters are electrically connected in series with said discharge.

16. The lamp as claimed in any one of the preceding claims further including thallium as a vaporizable metal species dispos d within said arc tube.

17. A method of controlling the radial distribution of vaporized metal species in a high

intensity discharge lamp arc tube comprising the inclusion within said arc tube of a selected quantity of a halide, other than a fluoride, of said metal species along with said metal species.

18. The method as claimed in claim 17 in which said metal species comprises sodium.

19. The method as claimed in claim 17 in which said halide comprises sodium iodide.

20. A discharge lamp as claimed in claim 1 substantially as hereinbefore d scribed with reference to and as illustrated in the accompanying drawings.

21. A method of controlling the radial distribution of a vaporized metal species in a high intensity discharge lamp as claimed in claim 17, substantially as hereinbefore described.

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